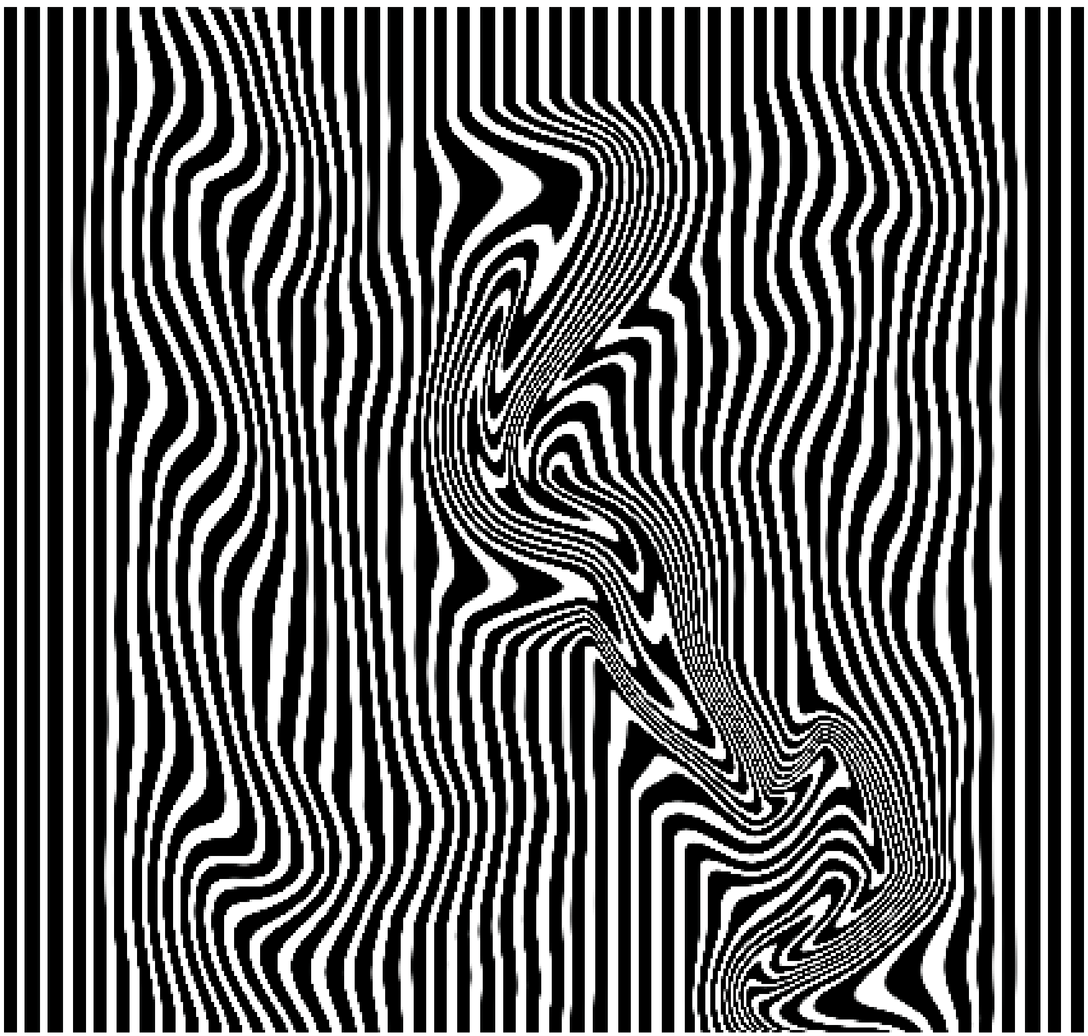
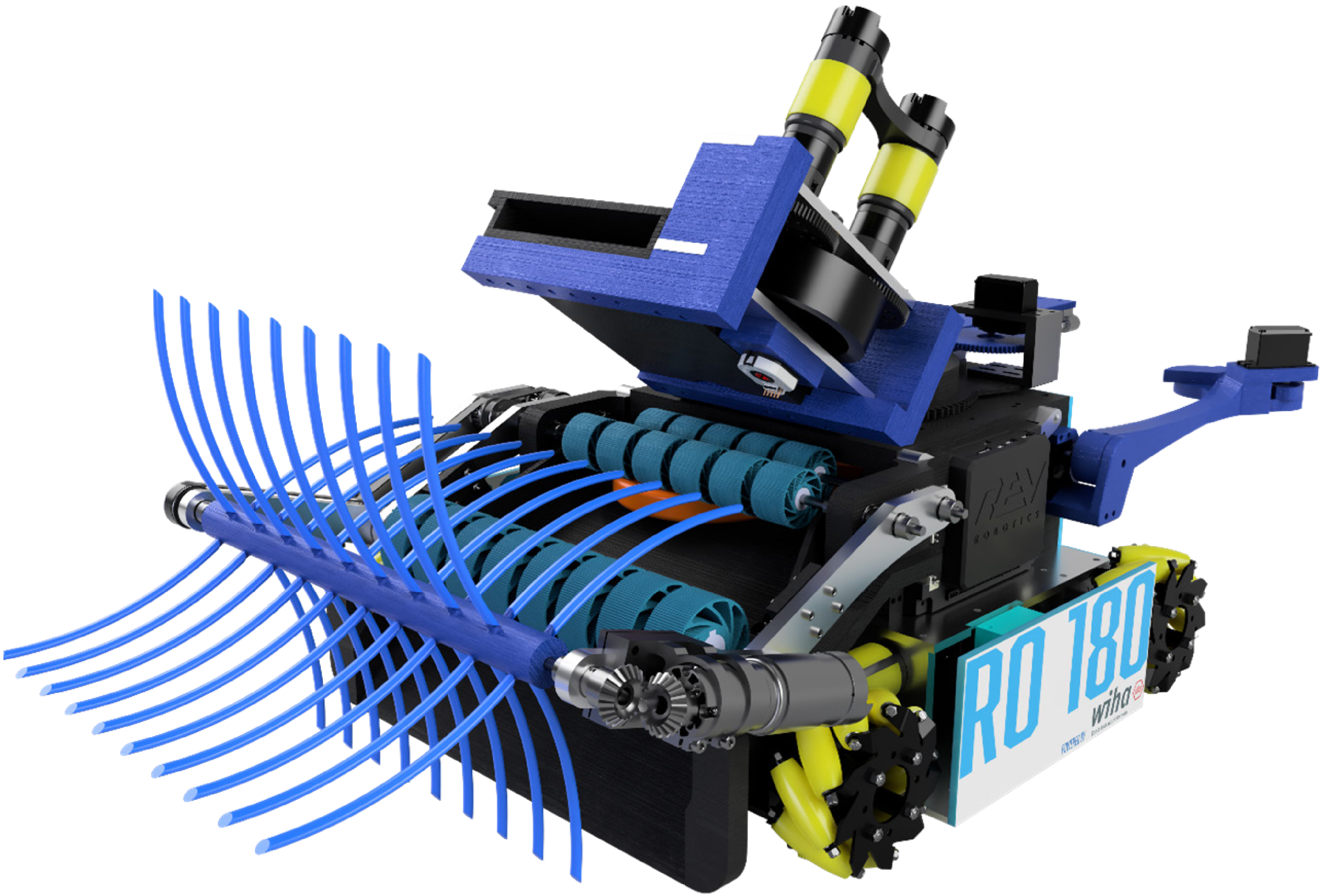


Herotech team

FTC edition

no. 2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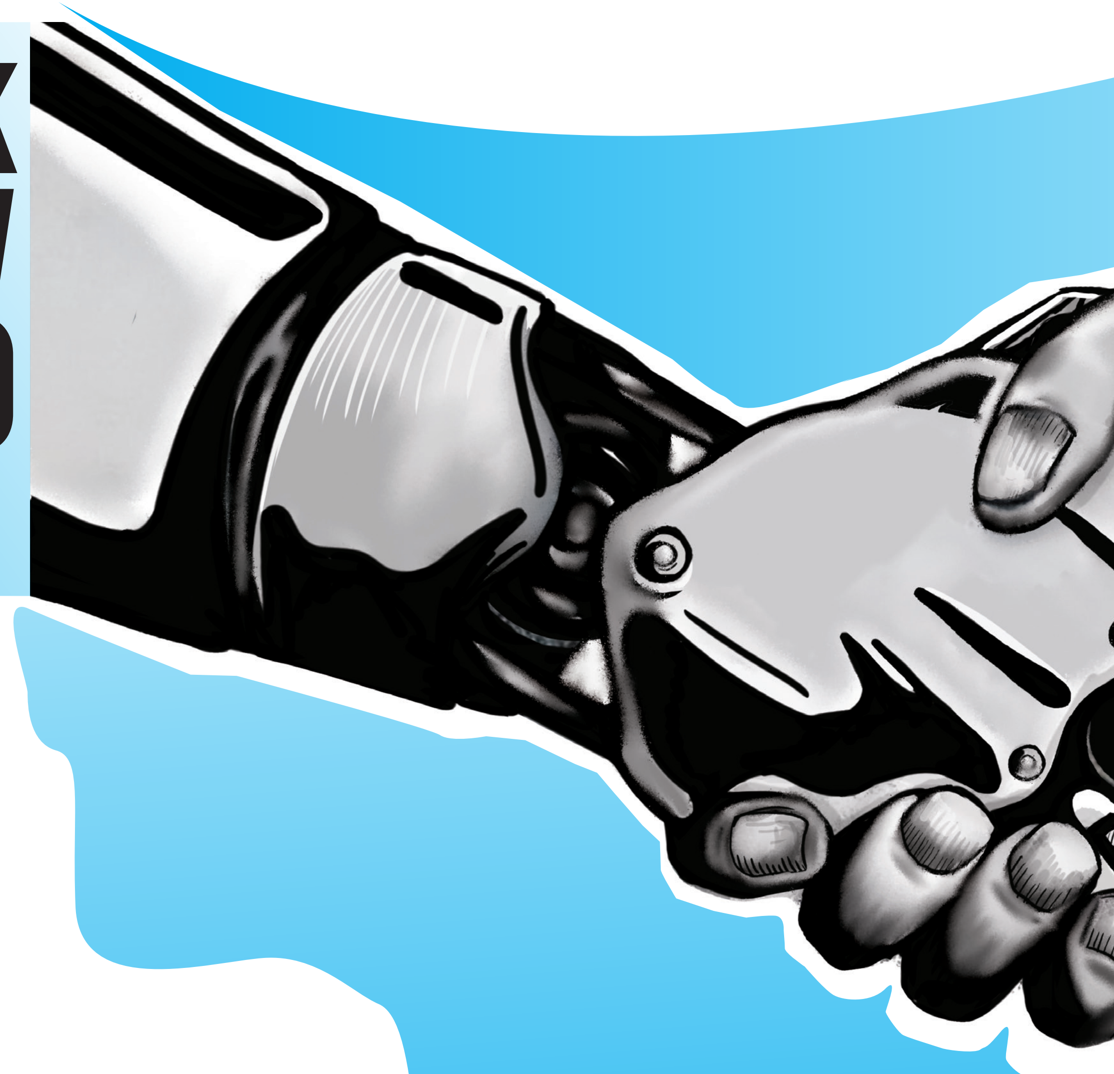

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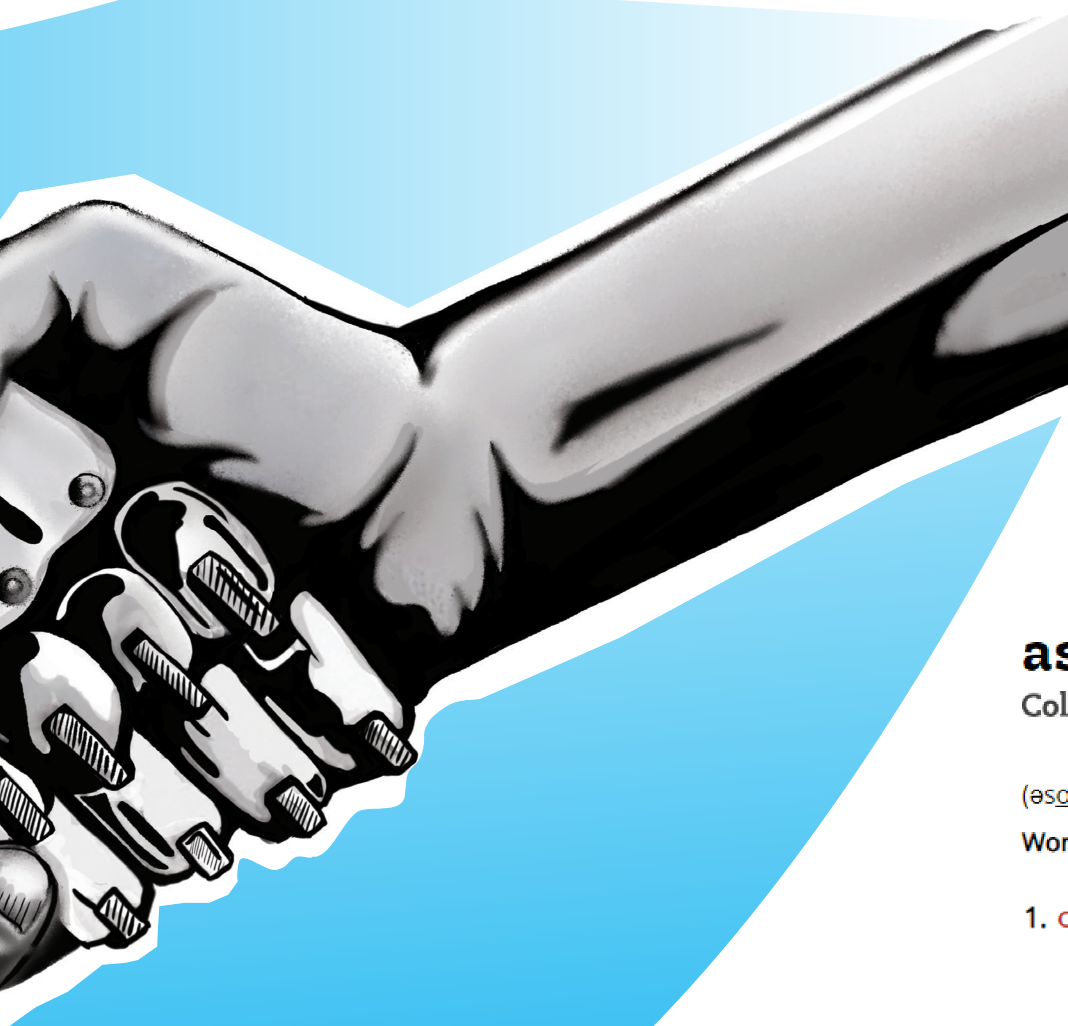
HEROTECH



IATION

association

Collins COBUILD

(əsoʊsieɪʃən)

Word forms: plural **associations**

1. COUNTABLE NOUN [oft in names]

   An association is an official group of people who have the same job, aim, or interest.

   ...the Association of British Travel Agents.

   Research associations are often linked to a particular industry.

01

3... 2... 1... ACTION!

"3... 2... 1... Action!" has been our motto for this year's competition as it challenges us to get out of our comfort zones, which is something that we found out we really needed after long and boring weeks of quarantine.

We are the robotics team Herotech, a rather new robotics team that is seen for the second time on the FTC scene. Last year was quite rough, what we mean by that is not only was it our first experience with FTC but also the pandemic season made its rather grandiose entrance in the worldwide scene, with it coming the end of all social activities.

Leaving all that behind, last year we had a lot of fun competing against other wonderful people that share the same passions and values as us. We remember with great pleasure the moments spent in the regional stage of the competition, but also the time spent together, as a team in the working space. With their departure from Herotech, which had only 6 members then, the team's structure was reduced to only 4 people.

0.1 INVESTING IN THE FUTURE

02 INTERVIEWS

beyond [bee-**ond**, bih-**yond**] SHOW IPA

See synonyms for *beyond* on Thesaurus.com

preposition

1. on, at, or to the farther side of:
   Beyond those trees you'll find his house.
2. farther on than; more distant than:
   beyond the horizon; beyond the sea.
3. outside the understanding, limits, or reach of; past:
   beyond comprehension; beyond endurance; beyond help.
4. superior to; surpassing; above:
   wise beyond all others.
5. more than; in excess of; over and above:
   to stay beyond one's welcome.

adverb

6. farther on or away:
   as far as the house and beyond.

0.1 DANIEL MARPOZAN

How do you manage your time?

"I'm very organized, each night I plan out the next day. I write everything on the note app on my phone, I set reminders and such, that's how I manage to do everything without forgetting something. I also leave sticky notes on my desk. I try to collaborate as much as I can with my team so that we don't sit around waiting for each other, to be efficient. If I have something to do alone for the electronics part, I set myself a deadline and respect it, even if sometimes it's hard to. All in all, I like what I do so I try to make time for everything."

Is it hard to learn for school and work for Hero-tech?

"No, because I know how to manage my time and I like what I'm doing. I'm not scared of the BAC exam; I want to focus on my projects this year."

How does a usual day sound for you?

"I wake up at about 6 am, I take a shower and all thatmorning stuff and then I go to school. Usually I waste my time at school, I sometime miss some classes either because I'm not interested at all in them or bcause I have more important things to do with my time. After school is over, if I have a large workload for the next day at school I go home and do it but there are some days in which I go to Wenglor and work on different stuff with the boys."

What are your hobbies and passions aside pro-graming?

"I like cycling and fishing. Also, I like to walk, preferably in nature, I like to go out with my friends and I really enjoy coffee."

What do your friends and family think about what you do?

" I think that both my friends and my family are proud of what I do but unfortunately lately I haven't been able to spend as much time with them, Wenglor is like a second home to me, I spend a lot of time here. My family is supporting me but also worry constantly about how late I get home if we have a lot of work to do. My friends think that what we do is complicated, we learned everything step by step, so I don't see it like they do."

0.2 CODRIN MUNTEAN

How do you manage your time?

"I don't really. I usually do anything but what I am supposed to while panicking that I won't have enough time to do what I know I have to, but when there's little time left, I really work hard, and I feel like I'm very productive. I start working at the beginning of an assignment, not being very invested in it and end up doing it in the last few days."

Is it hard to learn for your finals and work for Herotech?

"Not really. For now, I do not really stress about finals. Probably next semester I'm going to use more of my time to study. Obviously, there were times when I had to learn something for school and do stuff at our workspace and it was surely exhausting, but manageable."

How does a usual day sound for you?

"Well, it depends. If there is something we must work on, I'll probably spend at least half of my day at Wenglor. When there is nothing to code, because the team it's working on the hardware, I usually assist them or do research for the autonomous programming."

What are your hobbies and passions aside programing?

"I like technology and being in touch with the latest releases and researches. I love listening to music. There isn't a day where I don't open Spotify and shuffle one of my playlists, search for new music or listen to at least one podcast episode. I like intelligently crafted worlds, where mystery plays a big role and where you can uncover the secrets of it by paying attention to details, making connections and theorizing about it. I found these kinds of worlds in videogames (Dark Souls, Blasphemous) and manga's (Attack on titan)."

What do your friends and family think about what you do?

"My family and friends 100% support me and I like to think they are proud of my achievements."

0.3 ALEX RADAC

How do you manage your time?

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What do your friends and family think about what you do?

"My family and friends 100% support me and I like to think they are proud of my achievements."

0.4 SEBASTIAN BLEAJA

How do you manage your time?

"It would be an overstatement to say that I "manage" my time, I just try to be as productive as possible, sometimes I just procrastinate all day and get nothing done, all in all they balance out. I'm used to having a lot of activities at once and it sometimes feels just overwhelming but starting is always the hardest, it gets easier as you go on."

Is it hard to learn for your finals and work for Herotech?

"I would say that it is indeed scary to have finals and important tests on top of extracurricular activities, that being said, I don't think it's going to be that hard keep-ing things in control. All in all, looking at my past performances I don't need to worry a lot."

How does a usual day sound for you?

"I usually wake up at 6 am on school days, 10 am on days in which I have something to do, and 12 am in rest days. I have my first meal after one or two hours after I wake up. I like to plan out my day in a way that lets me interact as much as I can with people, socializing energizes me, if I stay indoors for more than two days I start to get really unmotivated and gloomy. I finish school at about 2 pm, it is also worth mentioning that my morning commute is done by foot even if I live far from school (about 4km). I don't usually go straight home after school, if I don't have any meetings to attend to or business to do, I go out with my friends.

I usually get home by 8 pm and dine with my family. "

What are your hobbies and passions?

"Until lately I loved representing people, all kinds of people, speaking in order to build a greater good. I was present in many social circles, from the student council to the county council, from volun-teering to a festival to preparing to take the interview of a great pianist. I consider myself outgoing and creative, if nothing else I have my imagination.

I always enjoyed writing, but I've only recently start-ed to do it a professional or competitive level. Writing is rewriting, exercising words, scrambling them, in such way that, at some point, after many hours, it will beget both clarity and style."

SPONSORS

03

civism

in British English

(ˈsɪvɪzəm)

NOUN

rare

good citizenship

Word origin

C18: from French *civisme*, from Latin *cīvis* citizen

0.1 OUR SPONSORS

0.1.1 WENGLOR

Wenglor is, and has been, one of our dearest partners for more than a year now! They are not only a family business, but they are also a family for us! The place where we have our workshop, where our projects take form, from concepts and blueprints, to real robots and innovative electronics! It feels like a second home for us, a place which holds a lot of dear memories and one that we could not do without! They helped us when we were in need, and they still support our work to this day! Back in 2018 they sponsored us for the first time for our participation at Genius Olympiad in New York.

After that, they financially supported our team during the last FTC Season, at a time when nobody else did! During a small discussion between Herbert, the general manager of the company, and our team, we mentioned that we did not have any place where we can work, so they offered us a very large space where now we spend most of our time.

They helped us with many CNC machined aluminium parts that we used for robot's construction! Also, they gave us a new solid box for robot transporation and helped us with the sensors we used in our projects! All the people from Wenglor are fantastic and we are very happy and thankfull for all their effort to support our activity!

wenglor
the innovative family

0.1.2 IT PERSPECTIVES

IT perspectives is a local software company that provides IT infrastructure and IT security frameworks. Their software is widely used by many customers in Europe and their area of expertise covers system development, analysis and design and cognitive robotic process automation (RPA). They are an important supporter in many community projects in our area. This year, we have the pleasure of collaborate with them for the first time, being sponsored for technical equipment.

0.1.3 SIEMENS

Siemens is our sponsor since 2019 and they continue to support our team! It is one of the biggest tech company in Sibiu and they work with new technologies and create solutions for many fields: health, automotive, mobility, energy and many others. Thanks to them and other sponsors we managed to equip our workshop with many tools that help us do our activity.

0.1.4 THIMM PACKING

THIMM Packing is a multinational company that provides cardboard transportation and high-quality sales packaging systems. It is the most important packaging provider in our area, with over 300 employees. Searching for a sponsorship for a new high-end workstation for CAD designing, we found this company and its manager, Vasile Sărac, was excited about our story and decided to help us. Also, one of our team members had the opportunity to visit their company based in Sura Mica Industrial Parc, a good chance to learn about how cardboard is made from cellulose to the final product.

0.1.5 DACODASOFT

Dacodasoft, the company that administrates the Romanian Transport Exchange Group, is an important sponsor in the current FTC season. They helped us with an important financial donation for mechanical and electrical components we need for our robot.

0.1.6 TOLUNA

Toluna Corporation is one of our main sponsors, supporting our team even in our toughest moments. We had the chance to find them in an educational program in Timisoara called "Youth Elite". They do market research for global brands such as Amazon, Sony, and Danone. We had the chance to visit their company in 2019 during the program mentioned earlier. We asked them if they can sponsor our team and the general manager, Raluca Barbu, kindly supported us in the previous FTC Season. Being qualified for the New York Genius Olympiad in the beginning of 2020, we started fund raising and Toluna was our first sponsor. Unfortunately, because of the COVID pandemic, the competition was postponed and in agreement with them we used the sponsored funds in order to offer our support in this critical situation by making face shields for our local hospitals.

Toluna

0.1.7 MITUTOYO

Mitutoyo is a global leader in precision measurement tools, being active in more than 20 countries. They offer a large scale of products and services for application that require remarkably high precision. Their technology is used in almost every industry and since their founding they continue to develop impressive new metrology solutions. Mitutoyo is active since 2011 in the Romanian market and the general manager of the local company offered us two precise digital calipers that are used a lot in our daily activity.

0.1.8 ADOBE ROMANIA

We use most of the Adobe software in marketing and PR and we are happy to have them as a sponsor! They help us with some licenses for the most used Adobe Products. Those licenses give us the possibility of making high end, professional digital work.

0.1.9 ASUS ROMANIA

Our first contact with Asus Romania was in summer 2020, when they became our partner. They support our team with their high-quality products! They gave us two laptops, which became the daily drivers of Alex and Codrin. One of them is a notebook which is used for programming and the other one in 3D modelling!

0.1.10 LENOVO ROMANIA

Looking for a mobile dedicated 3D modelling workstation for Daniel, we appealed to Lenovo Romania. We were impressed by their Thinkpad series, which is their best laptop category. Aurel Netin, the manager of the company did not hesitate to help us with a high-end Thinkpad given to us as a sponsorship. It is a pleasure for us to work with such an efficient device and overall we are truly grateful for their

0.1.11 DASSAULT SYSTÈMES - SOLIDWORKS

Dassault Systèmes is an exceptionally large software company that develops 3D software for 3D product design, simulation, manufacturing and much more. Their products are widely used in almost all industries, being the developers of the well-known solutions CATIA and Solidworks. They sponsor FTC teams with Solidworks licenses which saves us a lot of money.

0.1.12 3D CAD VEGRA

Our CAD designers have started this year, for the first time up until now, to use Solidworks. Before this we used Autodesk's Fusion 360 solution as our main CAD design software. After a summer practice at Continental Automotive Sibiu, we decided to switch to Solidworks, because it was used within the company and seemed more professional. They offered us some Solidworks tutorials then for free and we are very thankful for their help now!

0.1.13 ATOS IT SOLUTIONS

Atos is a global leader in digital transformation with 110,000 employees in 73 countries. European number one in Cloud, Cybersecurity and High-Performance Computing, the Group provides end-to-end Orchestrated Hybrid Cloud, Big Data, Business Applications and Digital Workplace solutions. With more than 2700 employees in Romania, Atos helps design the future of the information space. This year, Atos is sponsoring our team with equipment for our workspace. The equipment consists of an oscilloscope, a power supply, a function generator, a lab multimeter, and a hot air soldering station for SMD components. The devices mentioned previously are extremely useful in our electronics projects! We are extremely thankful for their implication; we feel blessed to be able to work with such a big company.

0.1.14 STAR ASSEMBLY

Star Assembly and Star Transmission are parts of the Daimler German concern. In Romania, they have two factories in Cugir and Sebeș, where they have some research and development offices too. They develop and manufacture high technology transmissions systems for the automotive industry. Many gearboxes used in Mercedes-Benz cars are manufactured there, in Romania, and we are proud of their professional work! They are sponsoring us with financial resources for a workstation that will be used by our loved colleague Sebastian who does a great job in editing this notebook.

StarAssembly

0.1.15 ASOCIAȚIA "MAINI UNITE"

We cannot find the words to express how much these people have helped us since last autumn. As we are not organized in a legal form yet, we cannot make any sponsorship contracts with companies. They support us for free with all the bureaucratic and legal presence needed so that we can benefit from sponsorships, which are our single financial income source. Thank you very much, Ana-Maria Micu for all the work you have done for us! Without her and the association we were not and probably still would not be able to participate in any competitions nor have any of the technical equipment we use today! They were and still are some of our best friends in this field of work and we cannot express the gratitude we feel towards them. They are highly active in our community, helping many people in need, which is genuinely nice of them, giving us an example to do the same!

0.1.16 MEDIA PARTENERS

Special thanks to all the journalists that helped us promote our achievements. From our point of view, it is particularly important for a robotics team to have a public presence, because it is one of the main ways to make themselves known in their local communities. As a result, we wrote about our results every time we won a prize or anything of that nature, keeping our community up to date with what was happening. This is also a way to raise funds, because the information reaches a large number of people, people that might be inclined to help us.

0.1.17 DEVIL DESIGN

Devil Design is a polish manufacturer of filament for additive printing technology. They are renowned for their quality at decent costs. Our team have the amazing opportunity to work directly with them, being supported with a wide range of filament materials and colors for our projects.

0.1.18 TESTO

Testo, with their headquarters in Germany, is a world market leader in the field of measurement solutions. They offer precise measuring instruments and innovative solutions for data management.
We are thankful for their support that consists of a thermal imager used in our electronics projects. The thermal camera has proved especially useful in the process of thermal management in electrical circuits.

0.1.19 ALBIS PLASTIC

ALBIS is one of the leading distributors worldwide. They offer market-leading product portfolios with standard polymers and sustainable products. They are one of our main partners since 2019 and our collaboration is excellent. They offered their support for the participation of our team at FTC Season 4, CanSat and FTC Season 5.

0.1.20 MILWAUKEE

Since the company began in 1924, Milwaukee Tool has led the industry in both durability and performance. With an unwavering commitment to the trades, Milwaukee continues to lead with a focus on providing innovative, trade-specific solutions (from www.milwaukeetool.com). Needing some powerful cordless equipment from our lab, we requested their support with proper equipment. They kindly gave us a set of cordless tools and all we can say is that their trademark – “Nothing but HEAVY DUTY” is perfectly suitable.

We enjoy using their tools in our activity and we are honored to have them partners in our projects.

0.1.21 BERNSTEIN

Bernstein is a German manufacturer of precision mechanic hand tools which are renowned for their ESD features. Their tools are used all over the world in many industrial applications. They kindly sponsored our team with some ESD safe tools such as: tweezers, pliers, screwdrivers, and a vice with ball joint holder. All these tools have proved particularly useful in our electronics projects and we are thankful for having them partners.

BERNSTEIN
TOOLS FOR ELECTRONICS

0.1.22 EASY INDUSTRY

Easy Industry is a local company that produces a wide range of metal parts using the most advanced technology available in the metal fabrication field. Their expertise covers the modelling side of a components as well as the production process. Easy Industry is one of our recent sponsors for CanSat.

EASY INDUSTRY
METAL FABRICATION

0.1.22 EEE SA AND KURTZ ERSA

EEE SA is a Romanian company that activates in the automation field. They offer a wide range of solutions for industrial applications, being a distributor for many companies in the electronics industry. They represent Kurtz Ersa in Romania, a German company that produces systems and equipment for the optimization of manufacturing processes. EEE SA and Kurtz Ersa helped our team with professional soldering equipment and other auxiliaries useful in our projects.

0.1.23 XEROX ROMANIA

Xerox is a pioneer in office technology, being renowned as the first manufacturer of paper copiers. Nowadays, Xerox means the house for many new technology solutions, from 3D printing to IoT and Artificial Intelligence. The Romanian branch sponsored our team with a multifunctional laser equipment which is useful for printing documents and the negative side of our PCB-s that are prototyped in-house.

0.1.24 AEROPART EXPERT

Aeropart Expert is a company that produces components for the aerospace industry, using the highest standards. They are our sponsors for the CanSat competition.

AERO PART EXPERT

0.1.25 RETRASIB SA

Retrasib is a company specialized in the manufacturing of equipment used in power grid. From 2014, Retrasib SA is parts of the SGB-SMIT Group, a leading transformers manufacturer in Europe, with around 1900 employees. They supported our team with a financial sponsorship for our participation at CanSat and FTC Season 5 as well.

RETRASIB
Your dedicated partner
of the SGB-SMIT Group

0.1.26 BSW METALS

Founded in 2007, BSW Metals is an authorized company for selling Nickel and Titanium semi finished products, such as: pipes, tubes, and bars in different shapes. They are supporting us for the CanSat project.

0.1.27 WIHA

Founded almost 80 years ago as a small family business, Wiha is nowadays one of the world's leading manufacturers of professional hand tools. They provide excellent products for industrial use, company culture being the key for their success. Their headquarter is located in Germany and the company is still run by the Hahn family. Thanks to their support, we are currently using the best tools available on the market in our projects!

0.1.28 WELLER

Weller is a German company, member of the American Apex Tools Group, with not less than 8000 employees in over 30 countries. The Weller name stands for pioneering solutions in soldering technology, being the most popular brand in this field. The German branch has sponsored our team this year with a professional soldering set and the quality of their equipment has made our work more enjoyable. We are grateful for having them with us!

0.1.29 WELLER

Hilti Group was founded in 1941 as a small family business and became one of the leading companies in the construction industry, They offer advanced technology for fastening, drilling, demolition, cutting, measuring, mechanical anchoring and many other applications. Their products are backed with a lot of research that led the company to success. Hilti's aim is to build a better future, being an agent of positive change to the world through their sustainability leadership. Hilti Romania is one of our recent partners and they equipped our lab wit a set of useful power tools. We are thankful for their implication!

0.1.30 TAGARNO

Tagarno is la global leader, delivering intelligent tools for specific applications in many fields (material science, agriculture, food, electronics). Their mission is to help customers maximize efficiency and improve their work with high quality digital microscopes. They use advanced technology to help their customers see smarter. Our team is involved in multiple projects that implies electronics prototyping. As the technology is continuously developing, the SMD components become smaller. We are currently working with small SMD packages in order to minimize the required space on our PCB-s. Hand soldering these components is quite challenging and we thought that a digital microscope would be a very useful equipment in this situation, because we could visualize the orientation of a small component and assure that every pin is properly connected to its pad. After a short research on the web, a TAGARNO digital microscope seemed the perfect solution for our team. After an online meeting with their team from Denmark, they understood our situation and kindly give us one of our high-quality products: a ZIP unit. At the time we are writing this text, the microscope has not arrived yet, but we are sure that it will be a great addition in our lab. We are thankful for their support and can't wait to use the microscope!

TAGARNO

04 TECHNICAL INFORMATION

1.1 PRE-DESIGN GOALS:

We started this project by firstly analyzing how the scoring system worked, how the match should (unravel), set a score target and many other pieces of information that should serve as our guidelines. After we laid everything down on a piece of paper, we set a few design goals for our robot:

-it should be able to vertically collect rings that are rolling from the (rack) towards the robot. This is a very important ability for our robot as it allows us to not have to move in the field because the rings always follow the same path after they fall, so we decided that staying in one place would be most efficient.

-it should have a way to automatically aim, so we decided to have a turret. Having auto-aim and fire is the fastest way to launch the rings and takes some pressure from the drivers. This was also a back-up plan in case we couldn't make the first goal work.

-it should be able to continuously collect rings while launching them. Having the ability to auto-aim and collect rings vertically, a continuous firing system should be quite easy to implement. We were wrong.

-it should also have the ability to stack 3 rings inside the robot and fire them fast. This was important for the start of the match when we would have had 3 rings already in the robot, and was also a more traditional back-up plan in case the continuous fire didn't work.

As we wanted to maximize our potential score, we also started by setting some limits. We decided that the limit for our human player is that he could at best place a ring in the field at 2 seconds intervals. This means that we would have a steady flow of rings, each spaced two seconds from another. Being able to only hold 3 ring at a time forces us to "process" a ring through the intake, lift and launcher every 6 seconds. The plan was to have multiple rings that go through the robot at different stages, for example: one ring is in the intake, one being elevated by the lift and one in the air going to the tower goal.

Combining this with the ability to collect ring while not moving would mean that we would have a very efficient robot, but we still have more work to do if we want to get there.

1.2 DESIGN PROCESS:

We mostly used Autodesk Fusion 360 to design the robot, but also Solidworks 2020 for less complex parts because we wanted to broaden our knowledge of CAD software.

We started with the base of the robot because we needed to know the boundaries and general shape. Before completely finalizing the base we moved to the rest of the assemblies because we were sure that we would have to modify it to some degree.

What we wanted to do was to be sure that what we designed will definitely work, and we wouldn't have to redesign an assembly from scratch. We managed to do this by using the Joints system in Fusion to its full potential. With joints such as Pin-Slot, Revolute, Slider and Rigid, we managed to simulate most of the movements that our robot could do, not to mention the use of complex combinations of tens of such joints for simulating the movement of the Lift system and others.

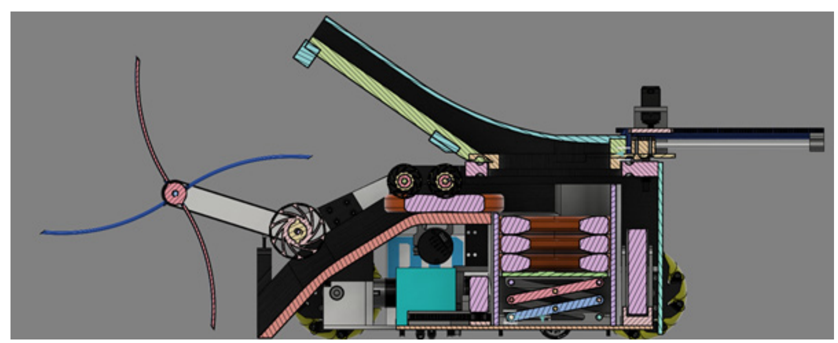
By seeing the exact movements in CAD, we were able to set clearances for our assemblies, so we wouldn't have anything with limited movement due to a design flaw.

An important thing we kept in mind throughout the design process was to make all assemblies sturdy and the connections the same. We didn't want to have to use any amount of duct tape or zip-ties to connect badly designed parts. We used lots of bolts and most components had twice the "required" amount of connecting points, such as the Intake with 24 bolts securing it to the Base & Neck Assembly.

Continuing with the "sturdiness" of the robot, we used as many "throughout" connections as possible. We have 25cm long screws that go from the Base to the top of the Neck assembly and connect numerous parts. This made it easier to connect assemblies to one another but required us to use 3mm pins in dedicated 3mm holes to firstly connect the assemblies together without any play, so the screws could tightened everything down in the exact position we wanted.

One thing we didn't think about and now we regret it is the fact we can't really access many of the more internal components and assemblies, such as the Lift system. This isn't a huge problem that affects the way the robot works, but in the few cases something failed, or we needed to change something, we had quite a lot of work to do. Not to mention "fishing" for a loose screw in the depths of the robot with a magnet tied to a string.

Lastly, we knew that we were able to 3D print most of the parts,



and also machine special aluminum or POM parts, which gave us the freedom to created very "weird" looking parts that would be very hard to machine, but also very strong parts that we couldn't create with a 3D printer. We are very thankful to the Mechanics Shop at Wenglor for all the help they offered us and the good advice when we needed it.

1.3 ROBOT BASE:

We started by placing the motors on the base in a way that would be as compact as possible. The first iteration of the base had the motors under the base plate, but as we need to be as low profile as possible (doesn't really look like we managed to) so we would need to lift the rings as little as possible, we moved the plate under the motors.

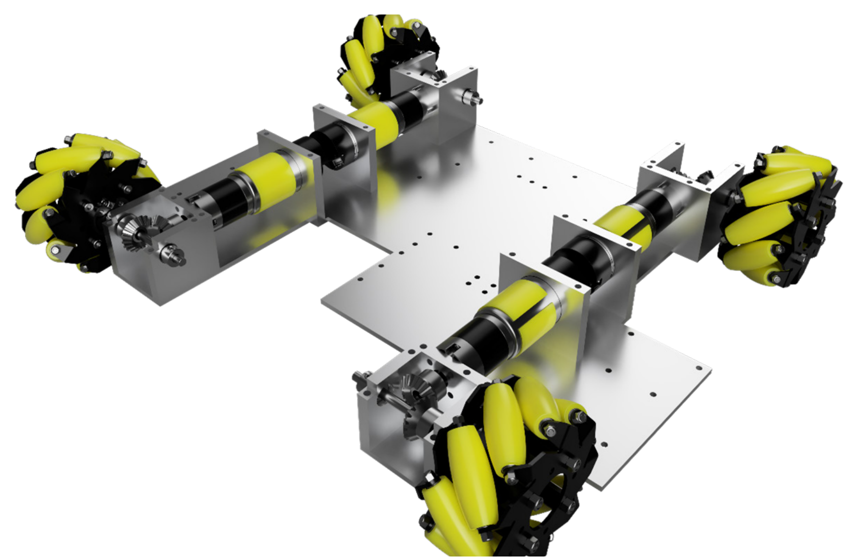
We use the Gobilda omni-directional wheels connected to 312 rpm Gobilda motors. This year we decided to no longer connect the wheels directly to the motor shaft, as it is definitely not good for the motors, so we placed them at a 90-degree angle using bevel gears with a 1:1 ratio. This also gave us more free space in the middle of the robot, where we needed it most.

The shape of the base is quite complex; It has multiple cutouts for different assemblies such as the odometers.

The motors are secured in 2 different places to assure they will not move and to prevent them from vibrating as much as possible. The plates that secure the motors also connect to the upper part of the robot, so everything is interconnected to some degree. This is good for sturdiness but bad for access, because if we wanted to remove some components we would have to remove parts of the robot that were also connected to them

Next, we had to choose the thickness of the base-plate. We talked to the engineers at Wenglor and the owner of Phoenix Laser, who advised us to use a 4mm aluminum plate, instead of the 8mm we thought of, which was overkill for the weight of the robot.

After the whole rest of the robot was completed, we were finally able to make the final holes in the base, as we didn't want to manufacture it before and then have to improvise rushed fixes and drill holes that could have been there from the beginning. The plate was laser cut at Pheonix Laser Sibiu, where we were for the entire process and learned a lot from it.



1.4 NECK ASSEMBLY:

This assembly is called "the neck" because it functions like a human neck. It rotates the "head" which is the turret and through it goes the "food", meaning the rings and its purpose is to house the large turret ring that functions as a giant bearing.

The top part has 2 semi-circular grooves on which the steel beads travel. On it the 117 rpm Gobilda motor is placed, which rotates the upper ringed-gear with a 6.2:1 ratio.

Both the upper and lower rings have the same type of semi-circular grooves for the steel beads. The rings are pressed together with bolts that go through them and are spaced with metal spacers, so the beads aren't too compressed.

We used special bearing grease to help reduce the friction when the turret is rotating.

As it may be obvious, the semi-circular groove is not the traditional type used in classic bearings, the normal type being either a V shaped cut or a $\prod$ cut, but as we were able to 3D print this part, a more complex, circular, cut was possible.

The neck also houses both the Control Hub & Expansion Hub on its sides, in a very accessible place.

The reason that the most important function of the neck is the rotation system is that the ring launcher is placed on top of it, automatically aiming the shooter using the odometry system.

The large space between the sides of the neck is necessary because that is where the Lift system is placed on the base.

1.5 WOBBLE ARM:

We went through numerous iterations of this system due to multiple causes. At first, the arm length was too short but as we increased it, the necessary torque of the servo increased, at the end needing about 14 kg-cm ,while our servo was a 15 kg-cm one. This is an awfully close match, but when we take in consideration the angular acceleration it is not nearly enough.

The first iteration with a long arm ruptured an internal metal gear of the servomotor, so we were forced to replace it.

For the next iteration we used a small gear hub where we switched from a direct connection from the servo to the arm to one with a gear ratio of 1:2.1. This provided the system with enough torque to lift de wobble, but our mistake was to use plastic gears, which in time inevitably started skipping.

The last iteration uses brass gears with a 1:2 ratio and a new, sturdier arm.

The gripper of this system went through some design changes as well, mostly the part that makes contact with the wobble. We tested many adherent materials, but in the end, we used some scrap of a 3D printed FLEX wheel and it worked just fine.

The gripper servo is attached to the closing part of the gripper with a plastic horn. We were able to change it to a metal one, but we found out that this makes the system a little bit safer for the servo. If the gripper doesn't "bite" the wobble properly, the servomotor still tries to close the gripper resulting not in a servomotor destruction, but a horn one, which is much better. There must be a better way to this, without sacrificing any part of the robot, but when we have to choose between a plastic piece which we have in abundance and a servo, the choice is easy.

1.6 INTAKE ASSEMBLY:

The initial goals for this system was, as stated above, to be able to collect rings vertically. We went through a lot of brainstorming to figure out what would be the best option to make the rings fall flat when they reach the intake. The solution we reached was to use some kind of circular brush that is soft enough, so the rings won't bounce back but sturdy enough to push them under it and then up the slope of the intake.

We tested some possible brushes but at some point, switched to tubes. We tried cable tubes, fishbowl air tubes, hose tubes and many others to find one that was right. In the end we tested some pneumatic tubes that worked perfectly.

Another important feature is the size of the intake. It has a 35 cm opening to collect the rings, which is critical because the rings have a little deviation from the normal path at times and if we want to not move an intake of a greater size was needed.

Two screws are present which adjust the height of the frontal tube brush to make it easier to find a position that collects rings the best in any orientation they might be (flat on the ground or vertical).

For this system to work we 3D printed numerous comply wheels from Flex of different diameters and designs to which worked better. After lots of trials, we decided to make our own design of comply wheels which had grooves on the outside and were less thick. We also used an adherent spray on them which proved extremely helpful.

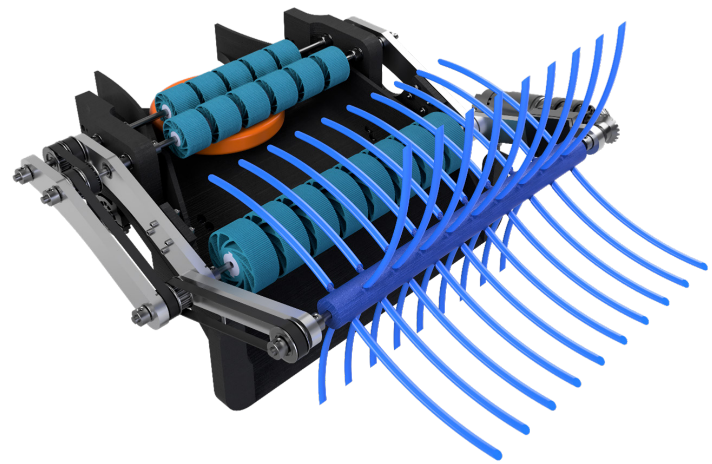
As it can be seen in the picture bellow, this assembly has two motors, a 435 rpm one that moves all the comply wheels and 223 rpm motor which spins the frontal tube brush. This wasn't always the case, as before there was only one single 435 rpm motor for both parts. We struggled to make it work with one single motor because we already reached the maximum of 8 motors on the robot. The biggest problem we faced was that the friction of the tubes with the ground was way too high and the system could barely collect one ring, and even then, the rpm of the wheels (which are all connected with a 1:1 ratio) was too low to push the rings in the Lift system which wasn't good at all. We were forced to remove one motor from the Launcher and move it to the intake. With this change done, the intake finally worked as expected.

The comply wheels are attached to the long D shafts with POM cores that tighten using hex screws. We switched to POM from PET-G because it wasn't strong enough and the wheel would start to slip after a time, needing to be tightened very often.

The frontal pneumatic tube brush goes outside the limit volume of the robot, but we made them to be "retractable". They can be put over the front wheels and the tubes bent inward to be sure they don't exit the volume.

Our biggest problem that still persists is that rings get stuck in the intake:

-the first place they get stuck is just before they get pushed into the lift system, the small wheels at the end don't move fast enough and are too far away from the lift too push the rings where they should be. We partially fixed this by placing 2 zip-ties on the last shaft, that poke the ring if it gets stuck and dislodge it most of the time.



-the second point where they get stuck is right before they get on the ramp. This happens when the rings are flat on the ground in places where the playing field isn't completely flat. The pneumatic tubes just brush over them and the only thing that we can do is to try and move them away from the problematic zone, but we can also adjust the screws to make the brush go lower, pressing harder on the rings and pulling them in.

-the third situation is when rings get stuck vertically in the intake. The brush can't push them down and we have to stop the intake and go back, making the rings fall to the ground. One solution to this problem is to collect the rings at an angle, which is quite hard to do for the drivers.

1.7 LIFT SYSTEM:

This system required days on end of brainstorming to get to. The system we had to design had to do a few things: be fast, be able to lift 1, 2 or 3 rings at a time, be reliable, be as low profile as possible and extend as much as possible. The latter conditions posed the biggest problem. We thought about a ton of possible solutions such as lateral bands, a slider-pulley system like the popular ones from last year competition, a threaded plate and many other... We felt that there was no good system that was 3 centimeters tall when closed and 20 when extended, but we still remember going to bed after a long day of designing the neck of the robot, when inspiration suddenly hit us and the idea to use a scissor type lift system finally came to mind.

We started by 3D printing one side of the lift to see if our design made from scratch could work and fortunately it did. We printed the rest and using a servomotor connected to a gear that converts circular movement to a toothed linear slider we made the system work.

It looked very shabby at first but after assembling it and doing a lot of testing it is one of the systems that works the best.

At times, rings can get stuck in the intake and when the lift tries to move them to the launcher the gear-slider starts to skip and the position of the servo is no longer the correct one. As this happened quite a lot in our testing, we changed the teeth on the slider to be a little slanted towards the lift. This allowed us to reset the position of the servo by simply forcing the lift to go back down, the teeth skipping back to their original position.

One problem we had was that the slider has to move 8.7cm to push the lift to the ideal height, which was a condition we didn't take in consideration, and because our servomotor was limited to a movement of 270 degrees, we had to make a bigger gear to be able to use the lift to its fullest potential.

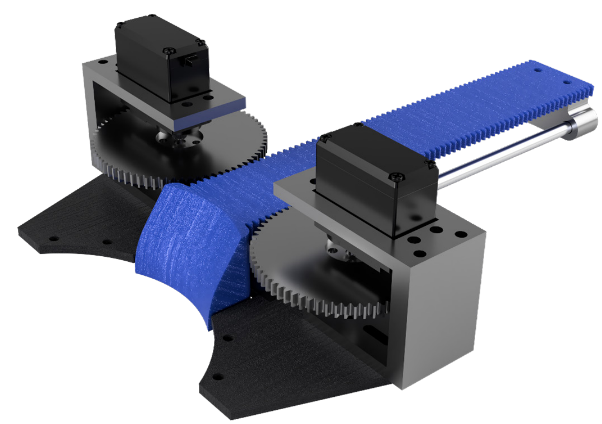
Another reason we chose this type of lift is that it is very fast. When it is at the bottom, a 2-degree change in the servo position result in the lift rising 3 centimeters. This grows slower as the lift rises higher due to the way this scissor system works, but it is still fast enough for us.

1.8 PUSH SYSTEM:

The push system is an assembly connected to the launcher, that has the purpose to push the rings from the lift, up the slope of the launcher as fast as possible.

The frontal part of this system has a little bit of an odd look. The shape has been created by cutting from a vertical block the movement that a ring does when it changes its position from the lift to the launcher (35 degrees). This makes the push system to always have full contact with the ring, no matter what angle the ring is in.

The first version of this assembly only had one steel rod and one linear bearing, but what quickly scratched because the bearings were not good at all (introduced more friction than letting the rod slide through plastic) and having only one bearing didn't offer enough stability.



We recreated the system to move on two separate bearings, we enlarged the gears to make the system faster and also changed the servomotors from high-torque to high-speed. The latter change made a big difference to how the system worked, speeding the push-pull time from 2 seconds to 0.5 seconds. Also, we bought some new bearings that were recommended to us a by an engineer at Wenglor, and all that we can say is that the difference was enormous for the difference in price.

Another thing we changed about this system is the way the servomotors are connected to the rest of the robot. Initially the brackets were 3D printed, but they would bend too much and the gears would skip, so we redesigned it with simple aluminum plates that are much more sturdy and we also implemented oval shaped holes to be able to tighten the gears and servomotors in.

1.9 THE TURRET:

This is the part of our robot that makes it special. It is a fully rotating turret that is limited only by the cables and is inspired by the turrets used on tanks. It uses the geared bearing from the neck to rotate around the center of rotation which is a ring in the lift. This means that the turret can be wherever we want it to be, and a ring will always be perfectly centered inside it. As a ring doesn't have a frontal or back part, it doesn't matter where we push it from inside the turret.

The previous assembly is directly fastened to the turret to assure that it is always aligned with it.

When the turret is aimed where we want it to be, the push system pushes a ring up the slope at a 35 degrees angle towards the fast-rotating wheel which will launch it at the tower.

Why is the slope 35 degrees? We calculated using the maximum rpm of the launcher motors how far could the robot launch a ring and found that 35 degrees is the minimal needed for our robot to launch a ring from the back of the field to the top goal.

Changing the angle of the ring when it is pushed up the slope was a little bit risky, but with a lot of care and using the slider joint Fusion 360 offers, we managed to create an upper part for the turret that is always at a maximum of 0.5 mm away from the ring, preventing it from going out of its path.

As it's quite a complex form we had to resort to 3D printing to create it. But, because it was too big

for our printers we had it made together with the intake from carbon fiber PLA at a specialist.
The biggest problem we had with it was the accuracy. After days of troubleshooting, we found out that we had to remove the wall after the wheel that launches the rings. We found this problem by inspecting the wall and seeing a small crevice that the rings made when exiting the launcher. That was a clear indicator that the ring was bouncing inside the turret after being compressed by the launcher. After it was removed the accuracy improved drastically.

1.10 THE LAUNCHER:

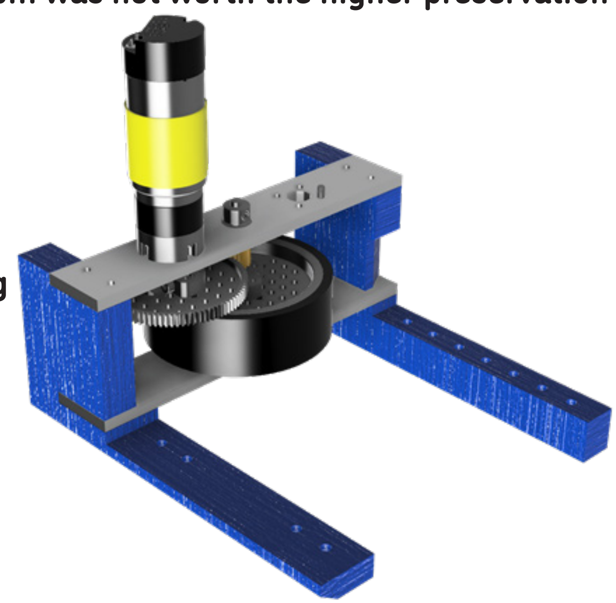
We first started by researching what RPM we would need to reach so we can launch the rings and how compressed should the rings be. We also thought about different types of launchers, like the 180 degrees one we spent a lot of time on but didn't use because it was huge.

After gathering all the data, we decided to use a single wheel, two 1620 rpm Gobilda motors connected with a ratio of 6 to 1, reaching a maximum rpm of 9720 theoretical RPM.

We had to give up one of the launcher's motors as we needed is for the intake, as mentioned above, but it wasn't a big problem at all, and we saw that it was pretty much useless to have two motors. After a ring would be launched, the motor would only need about 0.3 seconds to get back to the target velocity we needed to launch another ring.

One thing we experimented with was the launching wheel weight. We knew that a lighter wheel would reach the target rpm faster than a heavier one, but we also thought that a heavier one would lose less of its angular momentum after launching a ring. We were right, but the time needed for a heavier wheel to get to the rpm was not worth the higher preservation of angular momentum.

We use an encoder mounted directly on the shaft to have a very accurate reading of the wheel velocity for better aiming.



1.11 ODOMETRY:

For this assembly we decided to firstly search for encoders that were a good fit for us, and after browsing many forums, the AMT103-V capacitive encoders seemed to be a good option.

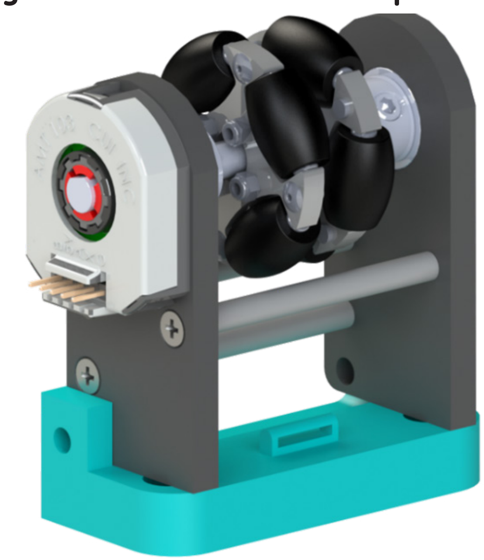
Firstly, these encoders are encapsulated in an aluminum shell that gives them more mechanical rigidity. Also, we can use any shaft between 2 mm and 8 mm because the manufacturer provides some collars meant to be attached on the shaft. The most important detail is that the shaft goes through the entirety of the encoder, so even if it moves it cannot damage the disc.

This encoder lets the user select the counts per revolution (CPR) anywhere from 48 to 2048, depending on the application requirements (motor RPM). This feature is implemented using a DIP Switch located inside the encoder, being easily accessible. The datasheet must be consulted to select the desired CPR.

Another advantage of these encoders is the materials quality: the cables and connectors are much stronger than optical encoder ones.

The problem we have is that odometry seems to lose accuracy relatively fast. We tried all that we could, from increasing the tension and pushing them harder in the field to tying them at a set position.

A problem that we managed to fix was the distance between the center of rotation and the frontal odometer. We measured the offset parallel with the sides of the robot from the center of rotation to the odometer, but we actually needed the diagonal line from the center to the odometer. This was a problem for us because the frontal odometer isn't right on the middle of the robot, so the data it reads was from a larger radius than the one we set. We found how to solve this by comparing the data the odometer read and the data it should read. From that data we managed to write a formula that uses the offset angle from the center of rotation and the diagonal line to calculate the parameters we need. Long story short, as the wheel of the odometer is not tangent to the circle created when the robot is rotating, its movement is split in two vectors, one useful parallel one and one useless, perpendicular one. This means the encoder was reading a wrong amount that could be corrected by multiplying it with 1/cos(angle between the center of rotation and the perpendicular on the odometer).



2.1 PROGRAMMING - AUTONOMOUS

Because this was our second year participating in the FTC competition, this time we came more prepared, and we consulted the community in regard of ways to program the robot. The unofficial FTC discord server was of great help for pointing out resources widely used by the community such as motion planning libraries. We decided to use acmerobotics RoadRunner library for autonomous path following because this was the most popular choice, and it also has integrated support for odometry. After we plugged in constants such as drivetrain wheel diameters, odometry wheel diameters, distance between the wheels, motor RPM, motor encoder ticks per revolution and more, we fine-tuned the feedforward, translation PID and heading PID controllers for the drivetrain, so that the robot can follow pre-programmed paths as smooth as possible.

Next, we started doing the autonomous programming. We used the three-wheel odometry for localization since we do not do any complex movements, so the heading calculation should be fairly accurate (0.2 degrees of error per autonomous execution). For each program we had constant things that had to be done such as: releasing the intake from the initial position with the help of the turret, parking as closely as possible to our shooting position from tele-op, shooting the preloaded rings into the high goal and delivering the wobbles to the required perimeter.

The 0 rings autonomous (71 points) is fairly easy since it is the one that requires the least amount of work to be done. The robot delivers the preloaded wobble to zone A. On the way to grab the other wobble it shoots the preloaded rings into the high tower goal and then delivers the wobble and parks itself on the line. The robot finished with about 8 seconds before the autonomous period time ends.

The 1 ring autonomous (83 points) is a bit more complicated since we have to get one more ring and transport the wobbles farther. The robot starts by releasing the intake while getting close to the ring placed down. Before getting the ring into the robot, it first aims and shoots one preloaded ring into the high goal so that the 3 rings limit is respected. The intake is trying to get the ring into the lift system while the robot goes to the wobble dropping point. After dropping the first wobble the rest of the program is the same as the 0 rings autonomy.

The 4 rings autonomous (71 points) is the hardest one since the wobbles need to be delivered to the other side of the field, but it is also the one with the most scoring potential since the field contains the greatest number of rings. We tried doing different things for this randomization case, but we quickly gave up on trying to collect the rings in the 4 stack, as they would often not fall properly into the lift system, resulting in the robot not being able to shoot them. This autonomous program starts with the delivery of the first wobble. The robot takes a longer path through the left side, in order to not bump into the 4 stack or the second wobble. Normally the quickest way to finish all the tasks would be for the robot to shoot the preloaded rings while going for the second wobble. But in this autonomous we decided not to do this because shooting a ring before the two wobbles are delivered opens up the possibility of a ring not going into the tower goal and falling close to zone C, which could present a risk if it's near the robot wheels. Instead, the robot delivers the two wobbles and then takes an extra path for shooting the preloaded rings. In order for the robot to complete all the tasks in time, we had to increase the velocity and the acceleration of the drivetrain (75% -> 90%).

For detecting the number of rings, we used the EasyOpenCV library. Firstly, we capture a 320x240 image and transform it from the RGB color-space to the YCrCb color-space. We draw a rectangular on the image (which is going to contain the stack of rings when the robot is in the starting position) and we compute the average value of the chroma blue channel from that pixels inside the rectangle. After that we do threshold segmentation in order to determine the number of rings on the field.

2.2 PROGRAMMING - TELE-OP

Firstly, we implemented a class for determining the state of buttons on the controller. The robot is checking for when a button is pressed down and only when the button is released, it executes the desired action.

Another important part of the controlled period is doing multiple things at once (such as moving while shooting rings). In order for this to be possible we implemented functions for each part of the robot which are called each main loop execution. These functions do not contain any loops or sleeps in order to not freeze the execution of the rest of the program. Instead, we used StateMachines and Timers to determine in which state a part of the robot is and how much time has passed since the state has changed. With this approach we implemented auto shooting of 1, 2 or 3 rings at the press of a button.

Another thing we tried to implement was auto turret aiming based on the robot position, so that the turret will always aim at the middle of the high goal. This sounds good in theory, and we managed to implement it, but odometry localization would lose accuracy pretty quickly with not so smooth movements such as those in autonomous. A partial solution to this problem was implementing a custom RoadRunner localizer written in Kotlin which uses 3 dead-wheels for determining X and Y position change and the IMU for the change in orientation. The benefit of this localization solution is that the orientation will always be accurate no matter what path the robot takes, so the error would not increase as much as it would if we would calculate the orientation based on the wheels encoder readings. Nevertheless, this is not a good enough solution for the turret aiming, since the robot would lose roughly 3-4 inches in both directions in a span of 30 seconds of robot movement.

The final approach we took is keeping the turret stationary and adjusting the position of the drivetrain before shooting. After the collection of 3 rings, we press a button that makes the robot generate and follow a path to the shooting point. We manually adjust the drivetrain position to match for the odometry error and then we set the new shooting pose to the one the robot is currently in. This solution seems to be the best alternative for auto-aiming and with enough driver practice the loss of time for repositioning the robot is insignificant.

HEROTECH

WE HAVE THE GOAL OF DEVELOPING AS MANY TECHNOLOGY RELATED SOLUTIONS AS POSSIBLE FOR IMPROVING EVERYDAY LIFE.